This part of implementation is based on Paper “A Retinex-based Enhancing Approach for Single Underwater Image” by Xueyang Fu, etc. As the underwater tends to be more blue or green owing the light refraction in the water.

are hyper-parameters.

The first part is color correction. We consider adjusting three channels separately. Calculating the mean and standard deviation of each channel and using parameter mu decides the maximum and minimum value of each channel. , . Then, based on the maximum and minimum, we tune the original RGB value by .

Since the variation of underwater environment is similar to the change of illumination, retinex method can be used to overcome the problem of under-exposure and fuzz. After the color correction, we decompose the original value , where S is the observed image, R is the reflectance, and I is illumination. R is bounded between 0 and 1, so we have We initialize the and as the Gaussian low-pass filtered image of . is the luminance layer of color corrected image. And initialize to be 0.

Next, we are going to tune value . Use matrix as the filters with to calculate . We define Using shrink function gets the updated derivative . Given updated , update by

where is Fast Fourier Transform operator, \* is the complex conjugate. All calculations are component-wise operators.

Next, we are going to tune value . Given updated , update by

In order to clip , .

To address the problem of under-exposure, a slight improved histogram specification is worked on the illumination . We Cumulative Density Functions (CDF) as

where is the zth gray level of , is the number of ith gray level. We define another CDF as

To lighten dark regions and preserve naturalness to avoid over-enhancement, . Finally we get . Then the new Lab color space is transformed into RGB to acquire the final enhanced color image. We use the same parameter as the write used, .